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Bargaining, Aggregate Demand and Employment

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Abstract

This paper depicts the negative impact of a falling real wage caused by reduced bargaining power of workers on aggregate demand and employment. Contrary to standard New Keynesian models, the presence of consumers not participating in financial markets (rule of thumb consumers) causes an immediate negative response of output and employment, which is amplified when the economy faces a lower bound on the nominal interest rate. Additionally, the paper shows that by supporting consumption demand, minimum wages might enhance output and employment.

Keywords: Real wage, search and matching, aggregate demand, household heterogeneity

JEL CLASSIFICATION SYSTEM: E21, **E24**, **E32**.

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1 Introduction

This paper presents a DSGE model in which a negative bargaining shock leads to lower employment level through its negative effect on consumption and aggregate demand. This result stands in contrast with standard New-Keynesian models with search and matching in which a similar experiment yields opposite results.[1] The main reason is that the feedback channel going from labour income to consumption decision is missing in the standard New-Keynesian model. Hence, this paper contributes to the literature connecting labour market and the business cycle by showing that the effects of a bargaining shock on employment depend on the relative strength of the supply side and demand side transmission channels.

The empirical literature points to the need to better understand the role of labour market shocks for the business cycle, bargaining shocks in particular. Ravn and Simonelli (2008) shows that technology and policy shocks have difficulties explaining some features of labour market adjustment over the business cycle.[2] Justiniano and Michelacci (2011) estimate a RBC model with search and matching for the US and 5 European countries. They find that there is large cross-country variation in the contribution of technology shocks to labour market fluctuation. Technology shocks work well in the US but results are mixed in Europe. Matching shocks and job destruction shocks play a larger role in Europe.[3] Using an extension of the Smets and Wouters model estimated for the US economy, Gali et al. (2011) point that wage markup shocks contribute significantly to output fluctuation in the short run and are the main driver of employment and unemployment fluctuations. Additionally, the importance of wage markup shocks is enhanced in the longer the time

[1]Examples of standard New-Keynesian models with search and matching includes Hall (2005), Shimer (2005), Ravenna and Walsh (2008), Gertler and Trigari (2009), Sala et al. (2008).

[2]Ravn and Simonelli (2008) apply a SVAR methodology to US quarterly data and consider four shocks: neutral and investment specific technology shocks as well as monetary policy and fiscal spending shocks. These shocks explain no more than 20 percent of the real wage and labour productivity forecast error variance.

[3]Matching shock accounts for 50(30) percent of cyclical fluctuations in unemployment in Great Britain (France), while job destruction shock accounts for 25(50) percent.

period considered.[4] Christoffel et al. (2009) point to the importance of bargaining shocks in explaining inflation and output fluctuations. Bargaining shocks explain 8 percent of output fluctuations in the short run and 16 percent of output fluctuations in the long run. The main reason is that bargaining shocks feed through wages directly despite price and wage rigidities.[5]

In the business cycle literature, the adjustment of real wage is an important determinant of unemployment. In standard New-Keynesian models with search and matching frictions and bargaining over income distribution a decline in the real wage increases output and employment. The main reason is that lower wages increase labour demand by firms. Since the surplus from an additional match accruing to firms increases, firms have an incentive to post more vacancies. A strong supply side effect follows, raising output. Additionally, changes in the real wage have no effects on consumption and saving decisions since the representative household receives both labour and profit income. Gali et al. (2011) provide a similar treatment of the role of wages looking at the effects of wage markup shocks in the Smets and Wouters model. They put forward that there is a positive co-movement between wage markup and unemployment. Excessive wage mark-up is seen as the main cause of the increase in unemployment in the 1970s and early 1980s as well as a significant factor contributing to the rise in the unemployment rate in 2011. Against this backdrop, Kumhof and Ranciere (2010) investigate the potential crisis-inducing impact of rising inequality following a negative bargaining shock. Workers react to falling wage income by increasing indebtedness, which eventually can cause an economic crisis.

[4]At 10 quarters horizon, wage markup shock is the third most important shock to account for output fluctuations (6 percent) and is the most important shock to account for fluctuation in employment (18 percent) and unemployment (41 percent). At 40 quarters horizon, wage markup shocks explain 17 percent of output fluctuations and 80% of employment fluctuations.

[5]Bargaining shocks explain 8 percent of output fluctuations in the short run behind risk premium shocks (60 percent) and monetary policy shocks (15 percent) far ahead of technology shocks (5 percent). Bargaining shocks explain 16 percent of output fluctuations in the long run behind risk premium shocks (48 percent) and ahead of monetary policy shocks (12 percent) and technology shocks (9 percent). Bargaining shocks also explain 12 percent of the forecast error variance of inflation in the short and medium run.

In contrast to this paper, Kumhof and Ranciere (2010) disregard the employment effect associated with lower wages as well as the aggregate demand effects by using a highly stylized model.

The model presented in this paper shows that a slight alteration of the standard New-Keynesian model with search and matching in the labour market and Nash bargaining over wages produces opposite conclusions following a bargaining shock. The standard New-Keynesian model is modified in two ways, which magnify aggregate demand channels.

First, the model creates a channel between income distribution and consumption / saving decisions using household heterogeneity. A first type of household is optimizing and makes consumption, saving and investment decisions to smooth inter-temporal consumption based on its permanent income. Additionally, a second type of household, called rule-of-thumb household, has no access to financial markets, and thus no saving or borrowing. This household relies exclusively on labour income when employed or the replacement wage when unemployed. Following a negative bargaining shock, lower real wage generates a decline in consumption and aggregate demand.

Mankiw (2000) calls for the introduction of rule of thumb households in macroeconomic models, arguing that consumption smoothing is far from perfect and that many people in fact have net worth near zero. Consequently, this idea has been introduced in mainstream economic models by many authors to discuss the effects of fiscal policy (see for example Galí et al., 2007; Cogan et al., 2010). Boscá et al. (2011) recently have combined rule of thumb households and search and matching, although they utilize a flexible price set-up. They underline that the combination of the two mechanisms better accounts for the characteristics of the US labour market. Rule-of-thumb households are also justified by empirical evidence showing that financial wealth is heavily concentrated in the top income deciles Atkinson et al. (2011).

Second, the paper introduces the possibility of a liquidity trap implemented with a lower bound on the nominal interest rate, as in Christiano et al. (2009). In a liquidity trap, a shortage of demand, causing deflation, cannot be met by a fall in the nominal interest rate. As a result, the real interest rate rises, further lowering consumption and investment demand. This paper shows that the negative aggregate demand effect caused by lower workers' bargaining power far outweighs the positive supply effects in a liquidity trap. Section 4 shows that the mechanism underlined in this paper are also relevant in the absence of a lower zero bound. However, the liquidity trap amplifies the mechanism at work.

Finally, the relevance of the feedback between incomes and demand is underlined by conducting an experiment where a lower floor on real wages is introduced. Such a floor can be motivated by the downward rigidity of nominal wages, or by policy action in the form of a minimum wage. Under such circumstances, the drop in employment induced by lower bargaining power is actually less severe since aggregate demand does not fall as strong.

Section 2 presents the mathematical derivation of the model used. Section 3 outlines the calibration strategy used, while Section 5 presents the simulation results. Finally, the last Section concludes.

2 Model

2.1 Households' heterogeneity and aggregate quantities

There are two types of households, optimizing households denoted by subscript o and rule of thumb households denoted by subscript r. We define the total number of households, consumption, employment and total labour endowment (labour supply) of each household type as Υ_i, $C_{i,t}$, $N_{i,t}$ and L_i for $i = [o, r]$, respectively. The total aggregate quantities are then given by the sums of these, thus $C_t = C_{o,t} + C_{r,t}$ and the equivalents.

Consumption per household $c_t = \frac{C_t}{\Upsilon}$ is then given by

$$c_t = \o_c c_{o,t} + (1 - \o_c) c_{r,t}, \tag{1}$$

where $\o_c = \frac{\Upsilon_o}{\Upsilon}$ is the share of optimizing consumers in the total population, and $c_{i,t} = \frac{C_{i,t}}{\Upsilon_i}$ for $i = [o, r]$. We assume that each household has a maximum labour endowment of unity. We also assume that rule of thumb households fully use their labour endowment, thus $L_r = \Upsilon_r$. For optimizing consumers, we assume that their labour supply can be a fraction υ, thus $L_o = \upsilon \Upsilon_o$.[6] This allows the model to encompass different cases. The standard rule-of-thumb set-up as presented in Galí et al. (2007) corresponds to $\upsilon = 1$. The polarized case where optimizing households are capitalists and rule of thumb households are workers as in Kumhof and Ranciere (2010) is given by $\upsilon = 0$. The standard New Keynesian model with a single optimizing households is achieved by assuming $\o_c = \upsilon = 1$.

The employment rate $n_t = \frac{N_t}{L}$ is given by

$$n_t = \o_n n_{o,t} + (1 - \o_n) n_{r,t}, \tag{2}$$

where $\o_n = \frac{\upsilon \o_c}{\o_p}$ is the share of optimizing consumers in the workforce and $\o_p = 1 - (1 - \upsilon)\o_c$. When $\upsilon = 1$, then $\o_n = \o_c$ and $\o_p = 1$. The aggregate employment per household is given by $\frac{N_t}{\Upsilon} = \o_p n_t$

Since only optimizing households hold a capital stock, per household investment and capital stock are defined as

$$x_t = \o_c x_{o,t} \tag{3}$$

$$k_t = \o_c k_{o,t} \tag{4}$$

2.2 Labour Market Flows

In the model presented in this paper, all households face equal probabilities of finding or loosing a job. Hence, we specify the labour market flows in aggregate quantities only. All workers not working in a period are unemployed and looking for a job. The pool of unemployed (relative to the labour force L) is given by $u_t = 1 - n_{t-1}$. Unemployed workers can be matched to a job and start working immediately in that period. The matching function (again specified as relative to the labour force L) is $m_t = \gamma_m u_t^{\gamma} v_t^{1-\gamma}$, where m_t are new matches, v_t are posted vacancies, γ is the elasticity of matching to unemployed workers and γ_m is the overall matching efficiency.

[6] We set this fraction exogenously. A model extension could have this value be determined endogenously, for example as a function of wealth.

Three definitions are used to describe the labour market: the probability of filling a vacancy, $q_t = m_t/v_t$, the job finding probability $p_t = m_t/u_t$ and labour market tightness $\theta_t = \frac{v_t}{1-n_t}$. The model assumes quadratic employment adjustment cost $\phi_{n,t}h_t$ following Gertler and Trigari (2009), which are specified in terms of the hiring rate $h_t = \frac{m_t}{n_{t-1}}$. [7]

Jobs separation probability is $1-\rho$. Employment at t is given by the remaining stock of workers plus new matches.

$$n_t = \rho n_{t-1} + q_t v_t \tag{6}$$

Thus, workers that were employed at $t-1$ and who loosed their job are immediately in the pool of unemployed and are able to find a job in period t again. The probability of filling a vacancy, q_t and the job finding probability p_t are given by:

$$q_t = \gamma_m \left(\frac{1-n_{t-1}}{v_t}\right)^{\gamma} \tag{7}$$

$$p_t = \gamma_m \left(\frac{v_t}{1-n_{t-1}}\right)^{1-\gamma} \tag{8}$$

2.3 Households

Optimizing and rule of thumb households maximize their inter-temporal utility function

$$\max U_{i,t} = \sum_{j=0}^{\infty} \beta^{t+j} u(c_{i,t+j}) \quad \text{for } i = [o, r], \tag{9}$$

where β is the time discount factor and the period utility function $u(c_{i,t})$ is defined as

$$u(c_{i,t}) = \frac{(c_{i,t} - \eta_h c_{i,t-1})^{1-\sigma^i}}{1-\sigma^i} \quad \text{for } i = [o, r].$$

Period utility includes habit persistence, governed by the parameter η_h. Both types of households face the employment dynamics constraint.

$$n_{i,t} = \rho n_{i,t-1} + p_t(1 - n_{i,t-1}) \quad \text{for } i = [o, r]. \tag{10}$$

[7] The functional form used is as in Gertler and Trigari (2009)

$$\phi_{n,t} = \frac{\kappa}{2} h_t^2 n_{t-1} \tag{5}$$

2.3.1 Rule of Thumb Households

Rule of thumb households do not have access to financial markets. Therefore, their budget constraint is given by their labour income plus their unemployment benefit payments w_u.

$$c_{r,t} \leq w_t n_{r,t} + w_u(1 - n_{r,t}), \tag{11}$$

The household maximizes its utility (9) subject to the employment and budget constraints, (10) and (11). The consumption of rule of thumb households is given by their budget constraint (eq 11), which is always binding. Furthermore, the marginal utility of consumption $\lambda_{r,t}$ (the Lagrange multiplier on the budget constraint) is given by

$$\lambda_{r,t} = (c_{r,t} - \eta_h c_{r,t-1})^{-\sigma^r} - \beta\eta_h(c_{r,t+1} - \eta_h c_{r,t})^{-\sigma^r} \tag{12}$$

The first derivative of the utility function $U_{r,t}$ with respect to $n_{r,t}$ yields

$$V_{r,t} = \lambda_{r,t}(w_t - w_u) + \beta E_t \left[V_{r,t+1}(\rho - p_{t+1})\right],$$

where $V_{r,t}$ is the Lagrange multiplier on the employment dynamics constraint (10), and can thus be interpreted as the marginal utility value of a job to a household. It is useful to define the value of a job in terms of a consumption good, thus we define $H_{n^r,t} = \frac{V_{r,t}}{\lambda_{r,t}}$. We then obtain

$$H_{n^r,t} = w_t - w_u + \beta E_t \left[\Lambda^r_{t,t+1} \left(\rho - p_{t+1}\right) H_{n^r,t+1}\right], \tag{13}$$

where $\Lambda^r_{t,t+1} = \frac{\lambda_{r,t+1}}{\lambda_{r,t}}$ is the stochastic discount factor for rule of thumb consumers.

2.3.2 Optimizing Consumers

Like rule of thumb households, optimizing households also earn labour income and unemployment benefits. These quantities have to be scaled by the relative labour market participation υ when expressing in per-household terms. Additionally, they can invest in bonds paying a gross nominal interest rate $R_{n,t}$. When $B_{o,t}$ is the total nominal quantity of bonds held by optimizing households, then $b_{o,t} = \frac{B_{o,t}}{P_t \Upsilon_o}$ is the real stock of bonds per optimizing household. Finally, they can accumulate physical capital $k_{o,p,t}$ subject to the accumulation function

$$k_{o,p,t} = (1-\delta)k_{o,p,t-1} + x_{o,t}(1-\phi_{k,t}), \tag{14}$$

where $\phi_{k,t}$ are investment adjustment costs.[8]

Optimizing households are allowed to vary the usage of physical capital by the factor $u_{k,t}$, to earn a return $u_{k,t}r_{k,t}$ on their physical capital stock. There is a cost $\Im(u_{k,t})$ associated with capacity over- or under-utilization.[9] Actual capital is determined by

$$k_{o,t} = u_{k,t}k_{o,p,t-1} \tag{15}$$

The budget constraint of optimizing households is given by

$$\begin{aligned} &c_{o,t} + x_{o,t} + b_{o,t} + \Im(u_{k,t})k_{o,p,t-1} \\ &\quad \leq w_t \upsilon n_{o,t} + w_u \upsilon(1-n_{o,t}) + r_{k,t}u_{k,t}k_{o,p,t-1} + \frac{R_{n,t-1}}{\pi_t} b_{o,t-1} - \tau_{o,t} + \Pi_t, \end{aligned} \tag{16}$$

where Π_t are profit receipts from firms, $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross price inflation rate and P_t is the aggregate price level.

The household maximizes its utility (9) subject to the employment dynamics constraint (10), the capital accumulation (14) and the budget constraint (16). We define the Lagrange multipliers on the employment constraint as V_o (thus the marginal value of a job), the budget constraint as λ_o (thus the marginal utility of consumption), and the capital accumulation constraint as λ_k (thus the marginal utility value of a unit of capital).

[8]Capital adjustment costs follow the usual specification $\phi_{k,t} = \frac{\eta_k}{2}\left(\frac{x_{o,t}}{x_{o,t-1}} - 1\right)^2$, so that $\phi_k = 0$ at the steady state.

[9]The functional form is $\Im(u_{k,t}) = \frac{r^k}{\psi}\left(e^{\psi(u_{k,t}-1)} - 1\right)$, so that $\Im(1) = 0$ and $\frac{\partial \Im(u_{k,t})}{\partial u_{k,t}} > 0$.

Defining $\varphi_t = \frac{\lambda_{k,t}}{\lambda_{o,t}}$ (Tobin's q), the first order conditions are given by

$$\lambda_{o,t} = (c_{o,t} - \eta_h c_{o,t-1})^{-\sigma^o} - \beta\eta_h(c_{o,t+1} - \eta_h c_{o,t})^{-\sigma^o} \tag{17}$$

$$\Lambda^o_{t,t+1} = \frac{1}{\beta}\frac{\pi_{t+1}}{R_{n,t}} \tag{18}$$

$$\varphi_t = \beta E_t\left(\Lambda^o_{t,t+1}\left[r_{k,t+1}u_{k,t+1} - \Im(u_{k,t+1}) + \varphi_{t+1}(1-\delta)\right]\right) \tag{19}$$

$$\varphi_t = \frac{1 - \beta E_t\left\{\varphi_{t+1}\Lambda^o_{t,t+1}\left(\frac{x^o_{t+1}}{x^o_t}\right)^2\left(\frac{x_{t+1}}{x_t} - 1\right)\right\}}{1 - \left(\phi_t + \frac{x^o_t}{x^o_{t-1}}\eta_k\left(\frac{x_t}{x_{t-1}} - 1\right)\right)} \tag{20}$$

$$r_{k,t} = r_k e^{\psi(u_{k,t}-1)} \tag{21}$$

$$V_{o,t} = \lambda_{o,t}\upsilon(w_t - w_u) + \beta E_t\left[V_{o,t+1}(\rho - p_{t+1})\right],$$

where $\Lambda^o_{t,t+1} = \frac{\lambda_{o,t+1}}{\lambda_{o,t}}$ is the stochastic discount factor for optimizing households.

Similarly to rule of thumb households, we define the value of a job in terms of a consumption good $H_{n^o,t} = \frac{V_{o,t}}{\lambda_{o,t}}$. We then obtain

$$H_{n^o,t} = \upsilon w_t - \upsilon w_u + \beta E_t\left[\Lambda^o_{t,t+1}(\rho - p_{t+1})H_{n^o,t+1}\right],$$

2.4 The Wholesale Good Firm

Wholesale good firms produce output using capital and labour using a Cobb-Douglas production function of the form $Y^w_t = F(K_t, N_t)$. Output per household can be expressed as

$$y^w_t = \left(k^\alpha_t(\o_p n_t)^{(1-\alpha)}\right), \tag{22}$$

where α is a share parameter.

The firm maximizes its value F_t, expressed as per household, by selling output at the real price p^w_t,[10] renting capital k_t at price $r_{k,t}$, and hiring labour n_t at price w_t, subject to the dynamic equation governing employment as well as the quadratic employment adjustment cost. The value is given by

$$F_t = p^w_t y^w_t - w_t \o_p n_t - \frac{\kappa}{2}h^2_t n_{t-1} - r^k_t k_t + \beta E_t\left[\Lambda^o_{t,t+1}F_{t+1}\right], \tag{23}$$

[10]Section 2.7 specifies p^w_t.

where $\Lambda^o_{t,t+1}$ is also the firms' discount factor as they are owned by optimizing households. The first order conditions with respect to k, h and n (where we do not evaluate $\partial h/\partial n$ as each firm is small) are given, in that order, by

$$r_k = p^w_t \alpha \left(\frac{y^w_t}{k_t}\right) \tag{24}$$

$$\kappa h_t = J_t \tag{25}$$

$$J_t = p^w_t a^n_t - \o_p w_t + \beta E_t \left[\Lambda^o_{t,t+1} \frac{\kappa}{2} h^2_{t+1}\right] + \beta \rho E_t \left[\Lambda^o_{t,t+1} J_{t+1}\right] \tag{26}$$

$$a^n_t = (1-\alpha)\left(\frac{y^w_t}{n_t}\right) \tag{27}$$

The marginal productivity of labour is given by a^n. J_t is the Lagrange multiplier on the "budget" constraint of employment dynamics (6), and thus can be interpreted as the marginal value to the firm of having another worker.

2.5 Bargaining

Firms and workers engage in Nash Bargaining over the joint surplus, the outcome of which is the wage w^*_t . η_t is the workers relative bargaining power and is time dependant since the experiment considered in this paper is a temporary shock on η_t.

$$w^*_t \equiv max \left\{ (H_t)^{\eta_t} (J_t)^{1-\eta_t} \right\}, \quad 0 < \eta_t < 1 \tag{28}$$

The bargaining solution implies $\eta_t J_t = (1-\eta_t) H_t$, where the aggregate worker surplus is given as a weighted average of the individual surpluses according to their share in the labour force, $H_t = \o_n H_{n^o,t} + (1-\o_n) H_{n^r,t}$.

The bargaining set, the total surplus, is given by $S_t = \bar{w}_t - \underline{w}_t$, where $\bar{w}_t$ is the maximum wage when firms' surplus $J_t = 0$, and $\underline{w}_t$ is the minimum wage when workers surplus $H_t = 0$. The negotiated wage is the weighted average of these reservation wages, $w^*_t = \eta_t \bar{w}_t + (1-\eta_t)\underline{w}_t$. By substituting $J_t = \kappa \frac{q_t v_t}{n_{t-1}}$, we obtain

$$
\begin{aligned}
w_t^* =&\eta_t \frac{1}{\o_p} p_t^w a_t^n + (1-\eta_t)\, w_u + \eta_t \frac{1}{\o_b} \beta E_t \left\{ J_{t+1} \Lambda_{t,t+1}^o p_{t+1} \right\} \\
&+ \eta_t \frac{1}{\o_p} \beta E_t \left\{ \Lambda_{t,t+1}^o \frac{\kappa}{2} (h_{t+1})^2 \right\} + \eta_t \rho \beta \left(\frac{1}{\o_p} - \frac{1}{\o_b} \right) E_t \left[\Lambda_{t,t+1}^o J_{t+1} \right] \\
&+ (1-\eta_t)\, \beta \frac{1-\o_n}{\o_b} E_t \left\{ H_{n^r,t+1} (\rho - p_{t+1}) (\Lambda_{t,t+1}^o - \Lambda_{t,t+1}^r) \right\}
\end{aligned}
\tag{29}
$$

Hall (2005) demonstrates that real wage stickiness greatly improves the ability of a search and matching model to match empirical employment dynamics. For this reason, we follow him by utilizing the following wage rule

$$
w_t = \rho_w w_{t-1} + (1-\rho_w) w_t^* \tag{30}
$$

The actual wage is a weighted average between the Nash bargained wage and the past period's wage.

2.6 The Final Goods Firm

The final good (expressed per household), y_t, is produced in a competitive market according to the following CES technology:

$$
y_t = \left(\int_0^1 y_{i,t}^{\frac{1}{\mu}} di \right)^{\mu} \qquad \mu \geq 1 \tag{31}
$$

where each input $y_{i,t}$ is a differentiated intermediate good. The term $\frac{1}{1-\mu}$ indicates the price elasticity of the demand for any intermediate good i. Each period, final goods producers choose a continuum of differentiated intermediate goods, $y_{i,t}$ at price $P_{i,t}$, to maximize their profits subject to the CES technology (31). The demand function for intermediate goods can be derived as follow:

$$
y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{\frac{\mu}{1-\mu}} y_t \tag{32}
$$

2.7 Intermediate Good Firms

Intermediate good firms purchase homogeneous goods from the wholesale sector and relabel them to produce differentiated goods. These differentiated goods are then sold in a monopolistic competitive market to the final good firms. Furthermore, we assume that intermediate good firms are subject to price stickiness, whereby a fraction χ cannot reset its price in a certain period and set price P_{t-1}.

The aggregate price P_t is given by $P_t^{\frac{-\mu}{1-\mu}} = \chi P_{t-1}^{\frac{-\mu}{1-\mu}} + (1-\chi)\tilde{P}_t^{\frac{-\mu}{1-\mu}}$, where $\tilde{P}_t$ is the aggregate reset price. Normalizing this equations by P_t, we get:

$$1 = \chi \pi_t^{\frac{\mu}{1-\mu}} + (1-\chi)\tilde{p}_t^{\frac{\mu}{1-\mu}} \tag{33}$$

where $\tilde{p}_t = \frac{\tilde{P}_t}{P_t}$ is the "real" optimized reset price.

Firms being able to optimize choose price $\tilde{P}_t$ by maximizing their discounted stream of real profits.

$$\max_{\tilde{P}_t} E_t \sum_{s=0}^{\infty} (\chi\beta)^s \Lambda^o_{t,t+s} \left[\frac{\tilde{P}_t}{P_{t+s}} - p^w_{t+s} \right] y_{i,t+s} \tag{34}$$

subject to the demand equation (32). p^w_t represents the (real) purchasing price of wholesale goods, and thus the marginal costs.

The first order condition is

$$f_{1,t} = \frac{1}{\mu} f_{2,t} \tag{35}$$

where

$$f_{1,t} = (\tilde{p}_t)^{\frac{\mu}{1-\mu}} y_t p^w_t + \Lambda_{t,t+1} \chi \beta \pi_{t+1}^{\frac{-\mu}{1-\mu}-1} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{\frac{\mu}{1-\mu}} f_{1,t+1} \tag{36}$$

$$f_{2,t} = (\tilde{p}_t)^{\frac{1}{1-\mu}} y_t + \Lambda_{t,t+1} \chi \beta \pi_{t+1}^{\frac{-\mu}{1-\mu}} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{\frac{1}{1-\mu}} f_{2,t+1} \tag{37}$$

Firms set their price not at the current optimal level but at the level they deem optimal over the expected lifetime of their set price. In the presence of inflation, this means that firms having reset their price earlier will have a lower relative price than firms that just reset their price, and will therefore have a higher share of aggregate demand. This means that there will be inefficiencies due to price dispersion, denoted with the symbol s_t. The quantity available for aggregate demand, y_t, is not necessarily equal to the quantity from the per firm production function y^w_t, but only a fraction $\frac{1}{s_t}$ of it. Hence, we have the relationships

$$y_t^w = s_t y_t \tag{38}$$

$$s_t = (1-\chi)\tilde{p}_t^{-\frac{1}{1-\mu}} + \chi \pi_t^{\frac{1}{1-\mu}} s_{t-1} \tag{39}$$

In steady state the optimal reset price will be given by $\frac{1}{\mu} = p^w$. Thus, firms set price as a mark-up on nominal marginal costs.

2.8 Policies and resource constraint

Due to the lower zero bound on monetary policy, the interest rate set by the Central Bank is the maximum of the interest rate as determined by a Taylor rule, R_t^{n*}, and zero.

$$R_t^n = \max\left[R_t^{n*}, 0\right] \tag{40}$$

The procedure for the introduction of a lower bound on a variable into a stochastically simulated model in Dynare is described in Holden (2011).

The Taylor rule sets the interest rate according to a criteria of interest rate smoothing, and measures of inflation and output. ϕ_m is the parameter driving the Taylor rule inertia, while ϕ_π and ϕ_y are the parameters setting the response of the interest rate to inflation and output.

$$\frac{R_t^{n*}}{R^n} = \left\{\frac{R_{t-1}^{n*}}{R^n}\right\}^{\phi_m} \left\{\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y}\right\}^{1-\phi_m} \tag{41}$$

The government pays unemployment benefits and finances these using lump sum taxes on optimizing households, which is thus equivalent to debt financing.[11] Therefore, rule of thumb households are not subjected to cyclical tax fluctuations. The resource constraint is given by summing the budget constraints of both type of households (11), (16) as well as the profit equation of firms.

$$y_t = c_t + x_t + \frac{\kappa}{2}\frac{q_t^2 v_t^2}{n_{t-1}} + \Im(u_{k,t})\o_c k_{o,p,t-1} \tag{42}$$

[11] $\tau_{o,t} = w_u\left(1 - n_{r,t} + \upsilon(1 - n_{o,t})\right)$

Finally, the exogenous process subjected to a shock ϵ_t in this paper is η_t, which evolves according to the autoregressive process

$$\eta_t = (1 - \rho_\eta)\eta + \rho_\eta \eta_{t-1} + \epsilon_t \tag{43}$$

2.9 Equilibrium

The stationary equilibrium consists in processes for the flow variables $[y, y^w, c, c_o, c_r, x, x_o, a_n]$, the stock variables $[n, n_o, n_r, k, k_o, k_{o,p}]$, the prices $[R_n, r_k, \varphi, u_k, w, w^*, p^w, \pi, \tilde{p}, p^*, f^1, f^2, s]$, the labour market rates $[q, v, p]$ and the utility and discount rates $[J, H_r, \lambda_o, \Lambda^o, \lambda_r, \Lambda^r]$, given the structural parameters $[\o_c, \upsilon, \sigma^o, \sigma^r, \beta, \delta, \psi, \eta_k, \eta_h]$, the labour market parameters $[\kappa, \rho, \gamma_m, \gamma, \rho_w]$, the production parameters $[\alpha]$, the pricing parameters $[\mu, \chi_1, \chi_2]$, the policy parameters $[w_u, \rho_m, \phi_\pi, \phi_y, \tau_r, \tau_o]$ and the exogenous process $[\eta, \rho_\eta]$ satisfying the equilibrium conditions given by equations (1), (2), (3), (4), (6), (10), (7), (8), (11), (12), (13), (14), (15), (17), (18), (19), (20), (21), (22), (24), (25), (26), (27), (29), (30), (33), (35), (36), (37), (38), (39), (41), (42) and (43) and the definitions $\Lambda^i_{t,t+1} = \frac{\lambda_{i,t+1}}{\lambda_{i,t}}$ for $i = [o, r]$.

3 Steady State and Parameterisation

The steady state of the model is given when all variables are constant over time. First, this paper calibrates a zero inflation steady state and normalizes the price level to unity. Next, this paper calibrates the job separation rate ρ, the job finding rate p and labour market tightness θ to match empirically observed values, and uses these to derive the structural parameters γ_m and κ. Furthermore, it is useful with production functions to normalize steady state output to unity. The steady state values k and n are easily derived using knowledge of the real interest rate (given the discount parameter β) and the job separation and finding rate.

Table 1 shows the parameter calibration used for the numerical simulations carried out further below. The parameters are essentially taken from Gertler and Trigari (2009), who estimated a similar model for the US economy. The relative risk aversion is identical for both households $\sigma^o = \sigma^r$ and is set at 1. It follows that the utility function takes the form of a logarithmic function. The time discount factor β is set at 0.992, generating an annual interest rate of 3.2%. Capital depreciates at a rate of 2.5% per quarter, which corresponds to 10% annual rate of depreciation. The investment adjustment cost curvature has been estimated to $\eta_k = 2.5$ by Sala et al. (2008) for the US economy, while Christiano et al. (2011) estimate a value of $\eta_k = 14.3$. We select $\eta_k = 11$ and the cost of capacity utilization is set at 0.5.

The parameters of the labour market are conventional and taken from Shimer (2005). The job surviving rate ρ is set at 90%, while the job finding probability p and the labour market tightness are equal to 0.95 and 0.5 at the steady state respectively. The elasticity of matching to unemployed workers γ is 0.5. An important parameter in search and matching models is the replacement ratio ω. In models without strong wage stickiness, a high value is needed to generate realistic employment fluctuations. Gertler and Trigari (2009) estimate this value to be 0.72 in a model with wage stickiness and 0.98 in a model without wage stickiness. We choose an intermediate value $\omega = 0.9$. Since restrictions are placed on two variables p and θ, the steady states for labour market variables are found by solving endogenously for the two parameters γ_m, the efficiency of the matching function, and κ, the employment adjustment cost. They are respectively equal to 1.345 and 0.6572. These parameters produce an employment rate n slightly more than 90% at the steady state. Finally, wage rigidity is moderate with $\rho_w = 0.3$.

[Table 1 about here.]

The capital share α is set at 0.3 and μ is set at 1.11 for a mark up of 11%, generating a labour share of income of 63% at the steady state. The set of parameters related to nominal price rigidities is conventional. 80% of firms are unable to adjust their price to the optimal price every period. Monetary policy inertia ρ_m is set at 0.8, while the reaction of the interest rate to inflation and output are 1.7 and 0.2 respectively.

Lastly, we conduct the experiment of temporarily lowering the bargaining power of workers from $\eta = 0.5$ to $\eta = 0.475$, with a persistence of $\rho_\eta = 0.9$. Due to the absence of evidence on fluctuations in bargaining power, the size of the shock was chosen to generate plausible variations in wages and the labour share. The bargaining shock produces a fall in real wage of 0.5 percentage point, which is similar to the weighted average drop in real monthly wages of employees in developed economies in 2011.

We define the baseline model when optimizing households' participation in the labour market is given by $\upsilon = 0.5$ to reflect the fact that part of the population actually only receives capital income. The share of rule of thumb households $(1 - \o_c)$ is 50% as in Galí et al. (2007). To simulate a standard New-Keynesian model, we set the share of optimizing households to unity ($\o_c = 1$, $\upsilon = 1$). We also consider another extreme case where all optimizing households are identified as capitalists, thus not earning labour income ($\upsilon = 0$).

4 Results

This section presents the simulated results of a fall in workers' bargaining power using the model described in this paper. First, the effect of such a shock is described in the baseline calibration with and without a lower nominal interest rate bound and compared to its effect in a standard New- Keynesian model. The main finding is that the conclusion from a standard New-Keynesian model, where lower bargaining power raises employment, is overturned when demand effects of wages are taken into account. Next, some sensitivity analysis to alternative parameter calibrations is conducted. Finally, the impact of the presence of a minimum wage in response to such a shock is analysed, showing that such a minimum wages, by supporting labour incomes, actually sustains employment and output.

The figures for output, consumption, investment and real wage below represent percentage point deviations in terms of GDP, which in turn is normalized to one in steady state. Inflation and employment are represented as percentage point changes.

4.1 Baseline results

The solid line in Figure 1 shows a standard New-Keynesian model with search and matching frictions, where the baseline calibration of Table 1 is altered to have only optimizing consumers ($\o_c = 1$ and $\upsilon = 1$). The dashed line represents the baseline calibration of Table 1. The dotted-dashed line additionally takes into account that the nominal interest rate can hit a lower bound in response to the fall in workers' bargaining power. Specifically, the interest rate is allowed to fall by 0.32 percentage points before hitting the bound, which represents well the current economic circumstances of very low interest rates.

[Figure 1 about here.]

The fall in bargaining power raises output, consumption, employment and investment in the standard New Keynesian model, while it lowers real wages and inflation. In contrast, output, consumption and employment initially fall in the baseline model. In the presence of a lower interest rate bound these falls are much more pronounced, with employment falling by 0.8% and staying below its initial level for 5 quarters. Additionally, the fall in real wages and in inflation are much more pronounced.

Two mechanisms are at work. The first mechanism is common to the baseline and the New Keynesian model (Fig 1 solid line). The fall in workers' bargaining power lowers real wages, which in turn implies a fall in marginal costs and thus inflation. Firms' surplus from employment relationships rises, thus increasing vacancies, the number of matches, employment and output. However, the labour share of income falls despite the rise in employment since employment adjusts only sluggishly. Additionally, countercyclical markups implied by New Keynesian price stickiness cause a rise in the profits, which add to the fall in the labour share of income.

The model presented in this paper takes a second mechanism, the aggregate demand effect from the fall in labour income, into account (Fig 1 dashed line). By lowering real wages, consumption demand from rule-of-thumb consumers falls. This causes a reduction in employment and output despite the positive supply side effect from lower labour costs. However, Figure 1 shows that the supply side effect quickly overturns the demand side effect, with output rising above its original level after 2 quarters.

When the economy faces a lower bound on the nominal interest rate, negative aggregate demand shocks can be strongly aggravated. This paper shows that the same holds for a negative demand shock induced by a fall in workers' bargaining power (Fig 1 dash-dotted line). Lower demand lowers inflation. However, in the presence of a lower bound, the nominal interest rate cannot fall further, thus raising the real interest rate. This in turn lowers investment and consumption demand by optimizing households. The economy faces a deflationary spiral. The positive supply side effect from lower bargaining power is overturned by its negative demand side effect.

Summarizing, a negative bargaining shock induces negative aggregate demand effects when one accounts for the importance of labour income for certain parts of households. When the economy faces a lower bound on the interest rate, as it does in situations of crises, this negative demand effect causes a strong fall in employment and output. This result stands in stark contrast to a standard New Keynesian model, where a fall in wage income only triggers a supply side effect, raising vacancy posting, employment and output. Accordingly, policy conclusions advising wage moderation in times of crisis might have to be reconsidered.

4.2 Sensitivity analysis

This section presents some sensitivity analysis to illustrate the importance of the different transmission channels at work in the baseline calibration. Figure 2 presents the sensitivity analysis concerning the impact of the income distribution as a driver of aggregate demand. The solid line shows the baseline calibration with a lower interest rate bound as presented above. The dashed line shows a calibration of limited labour market participation, where optimizing households behave purely as capitalists and do not participate in the labour market ($\upsilon = 0$). As a result, a larger share of total consumption cannot be smoothed intertemporally. A fall in bargaining power therefore leads to a larger fall in aggregate demand, and consequently to a more severe depression of economic activity. Furthermore, the model is moved closer to an instability region, thus producing a kink in the dynamic path of the variables.

The dashed-dotted line represents the case where there are no rule-of-thumb consumers, thus there is no demand effect from changes in the functional income distribution ($\o_c = 1$

and $\upsilon = 1$). However, the case still allows for the economy to be facing a liquidity trap. In this case, the increase in aggregate saving described above, combined with the fall in inflation, do not boost investment but cause the lower bound on the nominal interest rate to be binding. Compared to the baseline model, the absence of income distribution effects on aggregate demand diminishes the importance of the lower bound.

[Figure 2 about here.]

Figure 3 shows that the mechanisms introduced in this paper, the importance of the income of workers to support aggregate demand, induces a fall in output and employment after a fall in bargaining power even in the absence of a liquidity trap. The calibration has been changed to have no lower bound on monetary policy.

[Figure 3 about here.]

The solid line in Figure 3 corresponds to the baseline model. The fall in bargaining power has a stronger effect on the real wage, which, coupled with price stickiness and the impossibility of consumption smoothing, induces a stronger negative demand effect. In the absence of a liquidity trap, the nominal interest rate falls with inflation leading to a decline in the real interest rate. It follows that both labour demand and investment react positively. The speed at which output recovers is partly determined by the existence of capital adjustment costs, which delays investment decisions. Monetary policy shortens the recession by stimulating both supply and demand channels.

The dashed line in Figure 3 corresponds to a case in which there is no participation of optimizing households to the labour market $\upsilon = 0$. This polarized distribution of income between workers and optimizing households amplifies the wage-aggregate demand channel. Output declines by 0.7 percentage point and stays negative for 3 quarters. The fall in the real wage is also more pronounced around 1 percentage point.

The dashed doted line in Figure 3 shows the importance of nominal price rigidities. The transmission channel between lower consumption demand and output depends on the presence of price stickiness. Increasing price rigidity from 5 quarters to 8 quarters

($\chi = 0.875$) magnifies the demand side effects (dotted-dashed line). The fall in worker's bargaining power lowers the real wage further. Output and employment drop by 1 percentage point and 0.5 percentage points on impact respectively, while they both stay negative for 4 quarters.

4.3 Minimum wage as a lower bound on wages

Figure 1 has illustrated the importance of labour income for aggregate demand in the proximity of the lower zero bound in monetary policy. The transmission channel going from labour income to aggregate demand modifies the traditional views on a minimum wage. In a standard New-Keynesian model, the minimum wage is seen as hampering the downward adjustment in wages. This in turn limits labour demand of firms and amplifies business cycle fluctuations. Contrastingly, in the present model, the minimum wage sets a lower floor on labour income, which sustains consumption and aggregate demand. The direct negative effect of the minimum wage on labour demand is balanced by its positive impact on aggregate demand.

In this section, minimum wage is modelled in a similar way than the lower zero bound in monetary policy. The actual wage is the maximum between the wage rule (eq 30) and the minimum wage.

$$w_t = \max\left[w_t^r, w_{\min}\right] \tag{44}$$

with w_t the actual wage, w_t^r the wage according to the wage rule in (30) and $w_{\min}$ the minimum wage. The bound is set at 0.5 percent below the steady state wage.

Figure 4 reproduces the baseline simulation under the lower interest rate bound with (dashed line) and without a minimum wage (solid line) using the baseline calibration of Table 1. The main result is that the minimum wage reduces the size of the recession following a decline in the bargaining power of workers. The minimum wage reduces the drop in output from 1.25 percentage points to 0.5 percentage points on impact. The drop in the real wage is also smaller, 0.5 percentage points compared to 1.25 percentage points on impact. It follows that the drop in consumption is significantly lower than in the absence of a lower bound on wages, sustaining aggregate demand. A secondary effect is related to the adjustment in price. Since inflation declines less in the presence of the minimum wage, the increase in the real interest rate is more moderate, which is less detrimental to investment and labour demand.

[Figure 4 about here.]

5 Conclusion

The model presented in this paper shows that under certain conditions a fall in workers' bargaining power leads to lower employment and output. This result stands in contrast with the conclusion from a standard New Keynesian model, which finds virtue to wage moderation. The model reinforces the transmission channel from income distribution to consumption decisions by combining rule-of-thumb households and nominal price rigidities. This transmission is strengthened in the presence of a lower zero bound in monetary policy.

In the standard New-Keynesian model, labour demand is the main transmission channel. The increase in consumption and investment follows from the increase in employment and permanent income. Contrastingly, the present model takes the importance of labour income on aggregate demand into account by including rule-of-thumb consumers. Following a bargaining power drop, the demand and supply effect work in opposite directions. When the economy faces a lower interest rate bound, the negative demand effect is much stronger, thereby causing a significant fall in output and employment. Consequently, a minimum wage, by limiting the fall in labour income following a fall in bargaining power, supports aggregate demand and thereby reduces the fall in output and employment.

Two extensions to the present paper can be envisioned. The first is to allow workers to have some access to financial markets, and thus engage in some limited borrowing. This allows the study of the effect of inequality on household indebtedness, thereby following Kumhof and Ranciere (2010). Second, the extension to a two country model allows to study a number of research questions present on the current political agenda. In an open economy, a falling wage will additionally raise export demand, depending on the exchange rate regime. However, such a policy could be a beggar-thy-neighbor policy by raising unemployment in the foreign country. Furthermore, international imbalances might result. Given the results obtained in this paper, an interesting addition to the policy debate is likely to result from these extensions.

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Figures

Figure 1: Standard New Keynesian vs baseline model

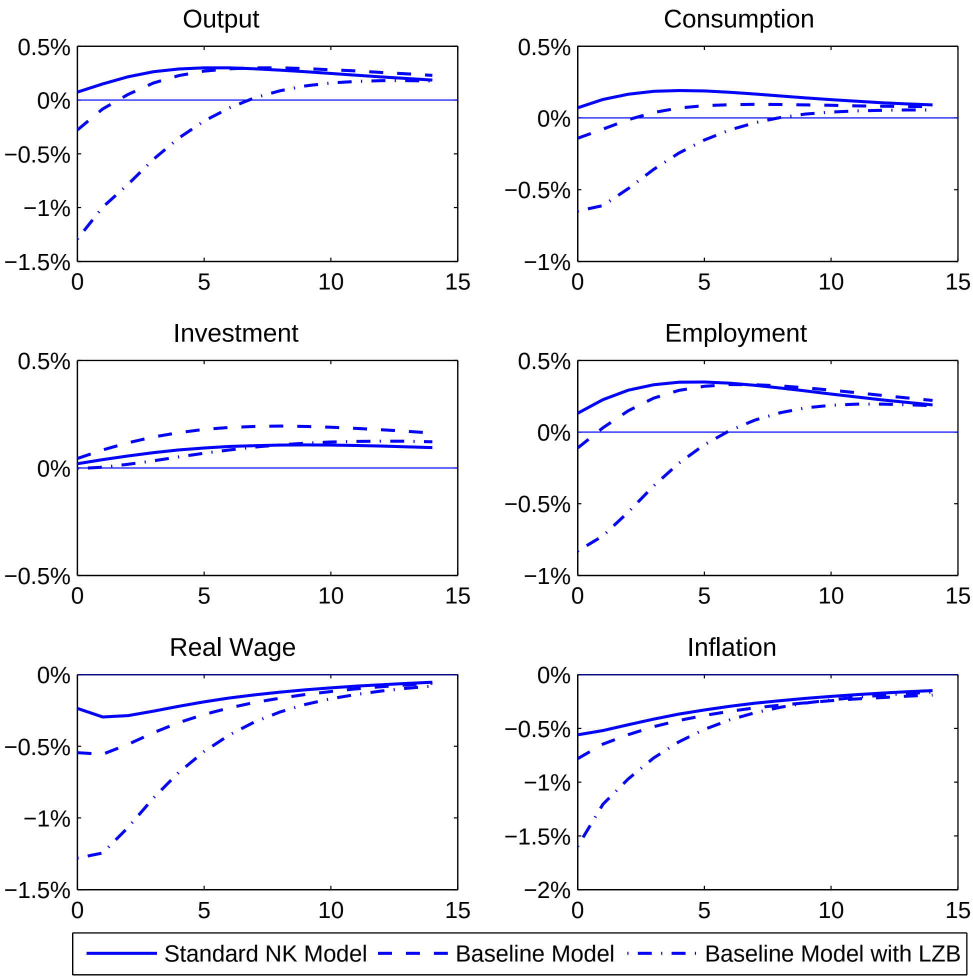


Figure 2: Sensitivity Analysis: Income Distribution

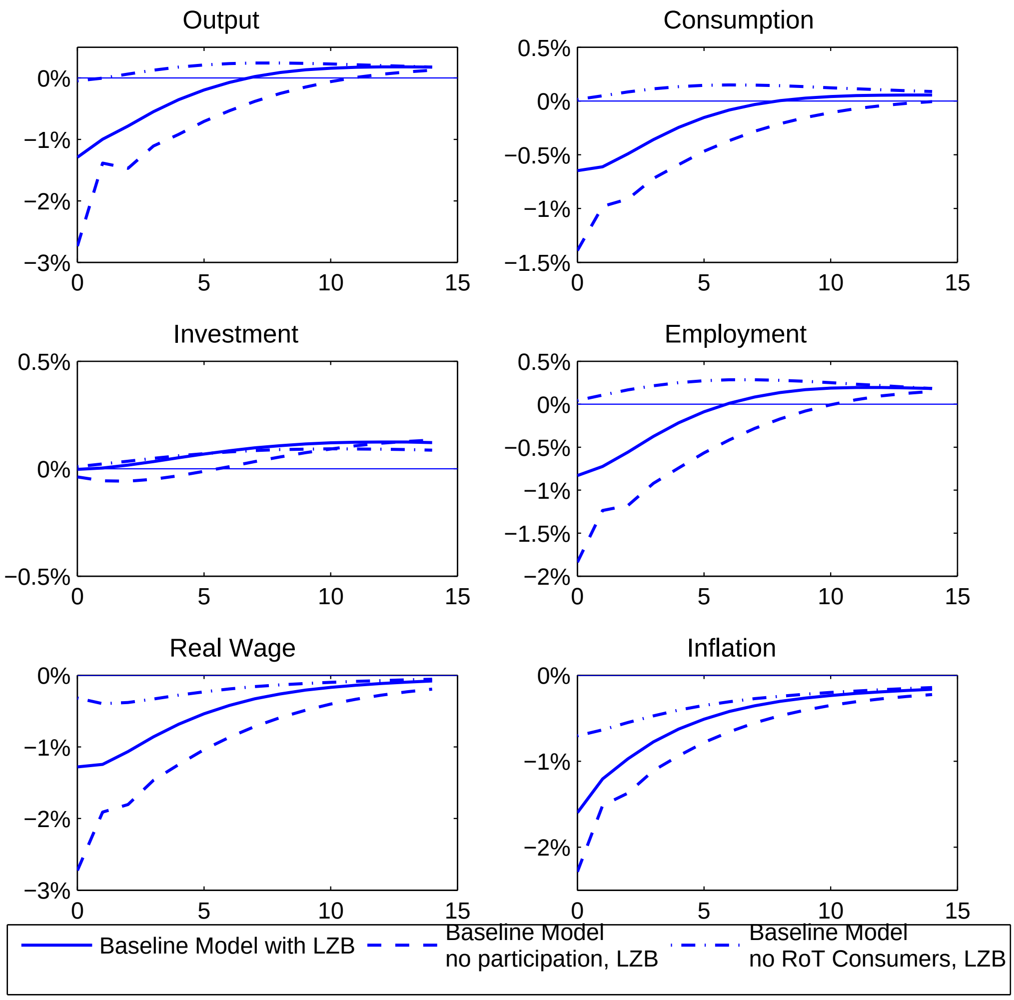


Figure 3: Sensitivity Analysis: Price Stickiness

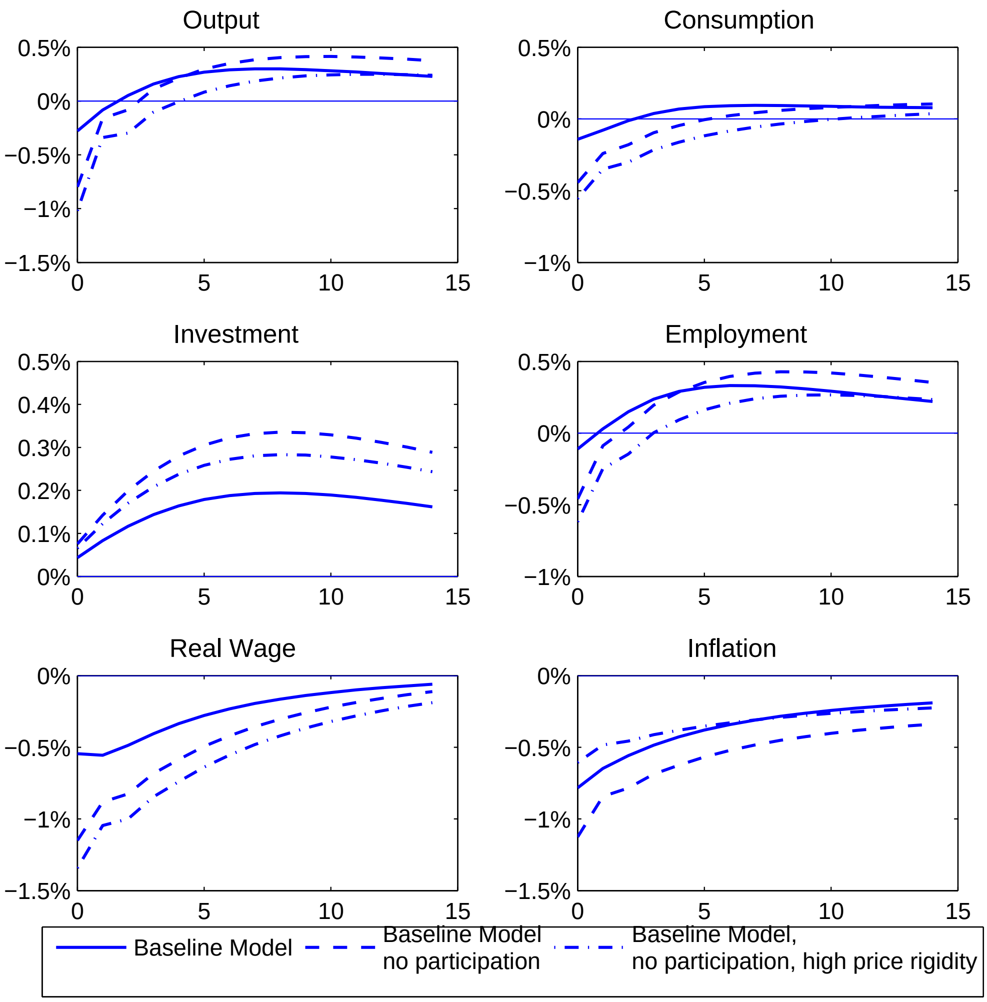
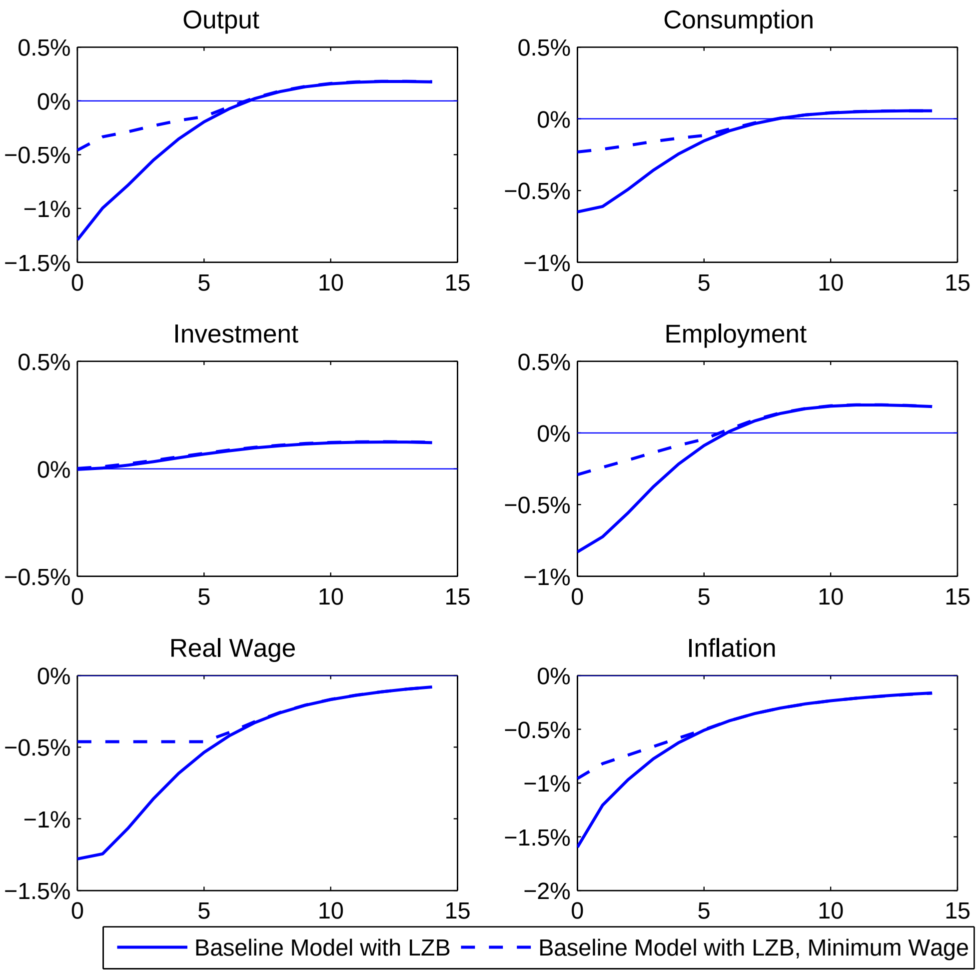


Figure 4: Minimum Wage



Tables

Table 1: Calibration: baseline model

Structural parameters	
Share of Optimizing Consumers	$\o_c = 0.5$
Labour market participation of optimizing consumers	$\upsilon = 0.5$
Relative risk aversion parameters	$\sigma^o = \sigma^r = 1$
Discount factor	$\beta = 0.992$
Habit persistence	$\eta_h = 0.5$
Capital depreciation rate	$\delta = 0.025$
Investment adjustment cost	$\eta_k = 11$
Capital utilization cost	$\psi = 0.5$
Labour market parameters	
Exogenous job loss probability	$1 - \rho = 0.1$
Target job finding probability	$p = 0.95$
Labour market tightness	$\theta = 0.5$
Matching elasticity	$\gamma = 0.5$
Implied matching function parameter	$\gamma_m = 1.345$
Implied employment adjustment cost	$\kappa = 0.6605$
Implied employment rate	$n = 0.9048$
wage rigidity	$\rho_w = 0.3$
Production and Pricing parameters	
Capital share	$\alpha = 0.3$
Price mark-up	$\mu = 1.11$
Price stickiness	$\chi = 0.8$
Policy parameters	
Replacement rate	$\omega = 0.9$
Interest rate smoothing	$\rho_m = 0.8$
Inflation response	$\phi_\pi = 1.7$
Output response	$\phi_y = 0.2$
Bargaining power	$\eta = 0.5$
Bargaining power auto-regressive coefficient	$\rho_\eta = 0.9$